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# DIRECTIONS FOR LABORATORY AND FIELD WORK IN ZOOLOGY


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# DIRECTIONS FOR LABORATORY AND FIELD WORK IN ZOOLOGY

FOR USE IN CONNECTION WITH

## PRACTICAL ZOOLOGY

BY

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# PREFACE

THE object of these laboratory and field directions is to furnish guidance for the observations that can be made with profit in connection with the writer's "Practical Zoology." That such guidance is necessary is obvious to every one who has attempted to teach zoology or to study animals. It prevents the waste of much valuable time and directs pupils into proper methods of attacking problems.

There are two chief reasons for separating the laboratory exercises from the textbook: (1) the pupils should not be tempted to depend upon their textbook to answer the questions that are asked in the laboratory, but should make original observations and then arrive at their own conclusions; and (2) teachers do not as a rule agree as to the order of the exercises or their contents, hence it is better to have the laboratory guide separated from the textbook in such a way as to enable the user to modify the order of procedure with the least possible confusion.

The great amount of material available for laboratory study has of course necessitated a selection of subjects. The animals included have been chosen with the idea of combining interest with profit so that the pupil may become acquainted with the common animals which he encounters more or less constantly in his daily life as well as with those that are of particular economic importance.

Zoological principles, however, have not been slighted, but have been introduced in their appropriate positions.

Many of the animals that are important economically are very difficult to obtain, and directions for the study of these have, of course, been omitted. These animals should, however, be demonstrated to the students whenever possible. A list of species suitable for laboratory study may be compiled from the textbook, and specimens may be obtained from the dealers whose names appear in the appended list.

Details such as topics for library study, questions for review, etc., have purposely been omitted from this laboratory manual in order that each teacher may have an opportunity to carry out his own ideas regarding these subjects. It has also been left for the teacher to decide which of the exercises should be shortened, or left out entirely, if the time necessary for studying them all is not available.

The methods of teaching zoology and physiology are ably treated in Part II of Lloyd and Bigelow's book, "The Teaching of Biology in Secondary Schools," published by Longmans, 1904. Price $1.50. Discussions of courses in zoology will also be found in current numbers and back volumes of the magazine "School Science and Mathematics."

Laboratory equipment and supplies may be obtained from the following dealers. Catalogues may be secured from them through a simple postal card request.

Bausch & Lomb Optical Co., Rochester, N. Y. Branches in many cities.

Spencer Lens Co., Buffalo, N. Y.

E. Leitz, 18th St., New York City.

Central Scientific Co., Chicago, Ill.

Eimer & Amend, 18th St. and Third Ave., New York City.

Cambridge Botanical Supply Co., Cambridge, Mass.

Kny-Scheerer Co., Ninth Ave., New York City.

Williams, Brown & Earle, Chestnut St., Philadelphia, Pa.

Ward's Science Establishment, Rochester, N. Y. Prepared specimens of all kinds.

Whitall, Tatum & Co., Barclay St., New York City.

Living and dead animals and microscopic preparations may be obtained from the following dealers:

A. A. Sphung, N. Judson, Ind. (Frogs.)

F. J. Burns, W. South Water St., Chicago. (Frogs.)

Louis Knoll & Sons, Washington Market, New York. (Crayfish, lobsters, clams, etc.)

Blackford's Market, Fulton Market, New York City. (Crayfish, crabs, clams, frogs.)

Brimley Bros., Raleigh, N. C. (Animal specimens.)

Kny-Sheerer Co., New York City. (Living and preserved specimens for class work.)

Western Biological Supply Co., Station A, Lincoln, Neb. (Microscopic slides. Living and preserved biological materials.)

F. Z. Lewis, Boys' High School, Brooklyn, N. Y. (Microscopic preparations.)

Marine Biological Laboratory, Woods Hole, Mass. (Preserved marine organisms.)

H. M. Stephens, Dickinson College, Carlisle, Penn. (Preserved marine specimens.)

# CONTENTS

# INTRODUCTION

**1. Instruments and Supplies.** The instruments and supplies necessary under ordinary conditions for doing laboratory work in zoology are as follows:

2 teasing needles (ordinary needles mounted on wooden handles will do).
1 scalpel, medium size.
1 pair of fine scissors.
2 medicine droppers.
½ dozen glass slides.
1 dozen ¾-inch cover glasses.
1 slide box for 25 slides.
1 piece of soft cloth for cleaning slides and instruments.
1 6H Kohinoor drawing pencil.
1 eraser with beveled end.
1 tablet of fine sandpaper for sharpening pencils.
1 laboratory loose-leaf notebook with note paper and drawing paper.

**2. Laboratory Notes.** All laboratory notes should be made in the laboratory at the time of making the observations. Nothing should be omitted in the exercises except by direction of the teacher. On the other hand, nothing should be included in your notes which is not the result of your own observations. If it is necessary to include other matter, this may be inclosed in parenthesis.

**3. Drawings.** There is no better way of becoming familiar with animals than by making drawings of them.

This not only aids in recording observations graphically but it also helps one to remember the observations he makes. Moreover, drawing is an exercise that teaches accuracy, and nothing is scientific that is not accurate. The making of scientific drawings does not require any special training or skill, and any one can succeed who carefully follows the following directions:

(*a*) Use a sharp, hard pencil making a firm, sharp, black line. Never use a blunt or soft pencil.

(*b*) Before beginning to make a drawing be sure that the object is not distorted in any way.

(*c*) Do not make the drawings too small. Examine your specimen, consider what parts are to be shown, and then make your outline so that all parts can be seen without difficulty.

(*d*) Drawings should be labeled. This may be done in two ways: (1) the name of the part may be printed at the end of the guide lines, or (2) a letter may be placed at the end of the guide lines referring to a fuller description in the lower left-hand corner of the page. In either case the labeling will look neater if the letters are printed. (See drawings in the textbook for examples.)

(*e*) Do not crowd the drawings on the page.

**4. Use of the Microscope.** Two kinds of microscopes are often employed in the laboratory study of animals. One of these, the dissecting microscope, is quite simple and no special instructions are necessary in order to use it. The compound microscope (Fig. 1) is more complex and more easily injured. It must, therefore, be handled very carefully.

*Never move the body tube while looking into the microscope*, as there is great danger of forcing the objective against the object that is being examined, thus injuring both.

In focusing, lower the tube of the microscope until the objective almost touches the cover glass; then, looking into the microscope, move the tube upward until the object appears distinct.

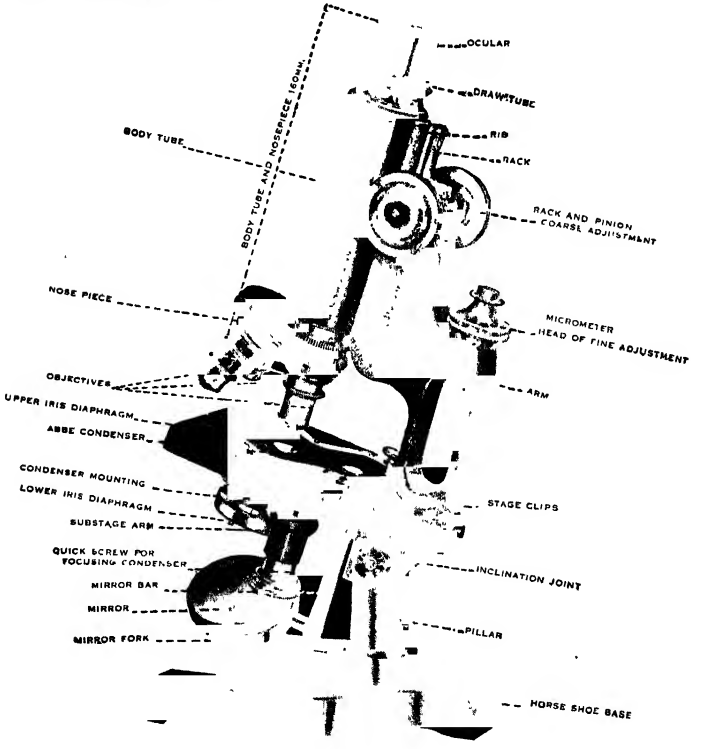


FIG. 1.

Learn to tilt the mirror and regulate the diaphragm so as to obtain the required intensity of light.

Determine what combination of the ocular and objective lenses gives the lowest magnification; what combination the highest, etc.

# LABORATORY AND FIELD WORK IN ZOOLOGY

## HOW TO COLLECT, PRESERVE, AND REAR INSECTS

### *A.* Collecting Insects.

*Materials.* The instruments most important for purposes of collecting insects are an insect net, a cyanide bottle, small forceps, one or more small bottles filled with 70 % alcohol, and a can or box in which living insects may be carried.

Insect nets (Fig. 2) may be purchased of dealers or may be made as follows. Make a circle about one foot in diameter of No. 8 wire. Solder the ends together into a tin thimble about five inches long and not more than an inch in diameter. Fasten to this rim a fifty-pound flour sack that has been thoroughly washed. Fasten a broomstick into the thimble and the net is complete.

Cyanide bottles are for the purpose of humanely killing the insects captured in the net. A wide-

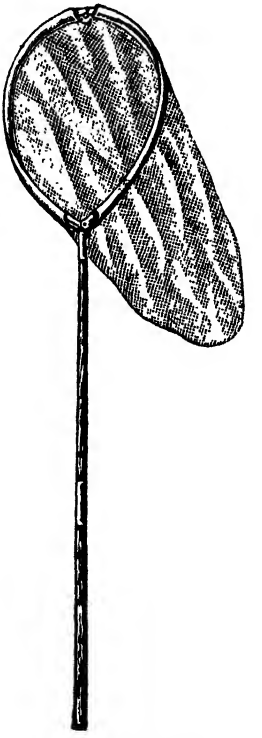

Fig. 2. — Insect net.

mouthed bottle or Mason jar may be used for this purpose. Cyanide of potassium is very poisonous and must be handled with great care. Take a piece of it about the size of a walnut and crush it into finer pieces. Place these in the bottom of the bottle or jar and pour on it enough moistened plaster of paris to cover it. Leave the bottle open until the plaster of paris becomes dry. Cover this layer with a circular piece of blotting paper which will keep the insects dry. Insects should be left in the cyanide bottle for from one half to three quarters of an hour. The fumes of the cyanide kill them with practically no pain.

Small bottles filled with 70 % alcohol will be found useful for the purpose of preserving soft-bodied insects, as well as caterpillars and spiders, that might be injured in the cyanide bottle.

Fig. 3. — Forceps.
Fig. 4. — An insect properly pinned.

Small forceps (Fig. 3) are a great help in picking up small insects. You can capture most insects by the hand without fear of being bitten, but the smaller forms are apt to be crushed between the fingers.

A can or box in which living insects may be carried completes the outfit of the collector.

*Where to find Insects.* Insects occur in almost every conceivable habitat. Many of them live in the grass near the ground and can be secured by sweeping the net back and forth through the grass. Others live in the foliage of trees and bushes and may likewise be brushed into the net by sweeping.

Great numbers of them, including ants, beetles, etc., may be captured under logs and rocks. These are all land forms.

In the waters of ponds and sluggish streams a host of aquatic insects make their homes. These may also be secured with the insect net.

***B.* Preserving Insects.** Insects that have been brought into the laboratory in the cyanide bottles should be taken out and immediately placed on insect pins. The pin should be forced through the middle of the thorax, and the head of it should project about one half inch above the insect so that it can be grasped when the specimen is to be moved from place to place (Fig. 4). Beetles should be pinned through the right wing cover, since if the pin is placed between the wings they will spread apart. The true bugs (Hemiptera) should be pinned through the triangular piece, the scutel, just behind the thorax. Very small insects may be glued to small triangular pieces of heavy paper. Many insects such as butterflies and moths possess wings that need to be spread out. This can be done with the help of a spreading board as indicated in Figure 5.

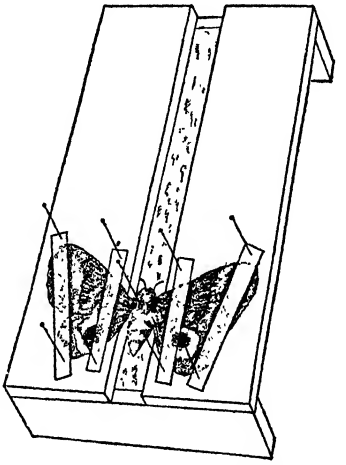

FIG. 5.—A moth pinned out upon a spreading board.

Insect cases can be purchased from dealers or may be made by the pupil. A cigar box or pasteboard box with

a layer of corrugated paper in the bottom will serve temporarily for a collection, but a more substantial case is necessary for the permanent collection. This case must be proof against the entrance of the little insects known as museum pests, which devour all sorts of dried insects.

Before insects are placed in the case provided for them, they should be properly labeled. Labels may be purchased or they may be made by cutting rather heavy white paper into rectangular pieces about $1\frac{1}{4}$ inches long and $\frac{1}{2}$ inch wide. The name of the insect, date of capture, food plant, and other items may be written on the label. Then the label should be placed on the pin near the bottom.

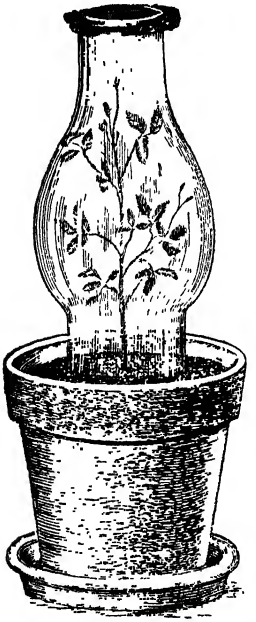

FIG. 6. — A flower pot, lamp chimney rearing cage for insects.

The best arrangement of the insects in the collection is according to their classification, placing those belonging to each order or family in one row.

*C.* **Rearing Insects.** Insects that feed upon leaves or other vegetation, or upon fruit, may often be easily reared in the laboratory. A very convenient breeding cage is shown in Figure 6. It consists of a lamp chimney embedded to the depth of an inch or two in the earth in a flower pot, and covered at the top with cheesecloth. The food plant of the caterpillars must be known and fresh food supplied daily.

## THE GRASSHOPPER

I. *FIELD STUDIES.*

(*a*) In what sort of fields do you find most grasshoppers?

(*b*) Upon what kind of plants do they feed?

(*c*) In what manner do you suppose they become aware of your approach? By sight, sound, etc.?

(*d*) How do they escape from their enemies? Why is it difficult to see them when they are on the ground or clinging to a leaf?

(*e*) Do you find any young grasshoppers? How do they differ from the adults?

II. *LABORATORY STUDIES.*

### *A.* Activities of the Living Grasshopper.

Grasshoppers should be brought into the laboratory and placed in some sort of box with glass sides in which grass and other plants have been placed.

(*a*) How do the colors of grasshoppers correspond to those of the ground and vegetation? Of what importance is this to the animal?

(*b*) Determine in what ways grasshoppers move about. How is the last pair of legs used? Do grasshoppers crawl?

(*c*) How do grasshoppers cling to blades of grass? Can you see any special structures on the feet which make clinging possible?

(*d*) Count the breathing movements of the abdomen of a grasshopper. Can you see the breathing pores or spiracles on the sides of the abdomen?

(*e*) Observe the position and movements of the antennæ or feelers of the grasshopper. What is their function?

(*f*) Watch a specimen eating a piece of vegetation and describe the movements of the various mouth parts.

### *B.* External Features.

#### 1. *Protective Covering.*

(*a*) Compare the external skeleton of the grasshopper with the internal skeleton of man.

(*b*) Does the skeleton allow movement of the parts of the body? How?

(*c*) Of what is the skeleton composed?

(*d*) Describe its colors.

(*e*) What are the functions of the skeleton?

#### 2. *Divisions of the Body.*

The body is divided into three principal divisions (head, thorax, and abdomen), each of which consists of many smaller parts.

#### 3. *The Head.*

(*a*) What is the size, shape, and color of the head?

(*b*) How is it attached to the thorax?

(*c*) Describe the antennæ or feelers, giving the shape, number of segments, position on the head, and functions.

(*d*) How many compound eyes are there? Where located? Shape? Color? Function? Structure? Why are they called compound? Cut a thin slice from the surface of an eye and examine under the microscope, noting the many similar hexagonal areas, the facets.

(*e*) How many simple eyes are there? Where located? Shape? Color? Function?

(*f*) Examine the mouth parts, noting their attachment to the head and the directions in which they can be moved. Then with forceps pull the mouth parts out one by one and place them in order as they are attached to the head. Be sure to grasp them at the base with the forceps, or only the ends will be removed.

(*g*) The labrum or upper lip. Shape? Motion? Function?

(*h*) The labium or lower lip. Shape? Motion? Function?

(*i*) The mandibles or jaws which lie just beneath the labrum. Number? Shape? Motion? How fitted for grinding up vegetation?

(*j*) The maxillæ or little jaws which lie just beneath the mandibles. Number? Shape? Motion? Function?

(*k*) Make an outline drawing of the front view of the head and label all the parts you can illustrate.

(*l*) Draw the mouth parts in the order in which they are attached to the head.

4. *The Thorax.*

The thorax consists of three divisions called the prothorax, mesothorax, and metathorax.

(*a*) Do they move upon one another?

(*b*) Which parts bear legs? How many?

(*c*) Which parts bear wings? How many?

(*d*) Which parts are provided with breathing pores or spiracles? How many?

5. *The Legs.*

(*a*) How many pairs?

(*b*) Are they all alike in size and number of segments?

(*c*) Of what use are the claws and pads on the end segments, the tarsus?

(*d*) What are the functions of the last pair?

(*e*) Draw one of the last pair as seen from the side and label all the parts.

6. *The Wings.*

(*a*) How many pairs?

(*b*) Where attached?

(*c*) Compare size, shape, and structure of the two pairs.

(*d*) Functions of each pair?

(*e*) What is position of the second pair when at rest? When the insect is flying?

(*f*) What stiffens the wings? Are the veins constant in number and location?

7. *The Abdomen.*

(*a*) Number of segments? Do the segments move on one another?

(*b*) The first segment bears a pair of tympanic membranes. Function?

(*c*) How many spiracles are there on the abdomen? Location? Function?

(*d*) If your specimen is a female, you will find an ovipositor at the posterior end. Function?

(*e*) Draw side view of abdomen, labeling all parts.

### C. Internal Organs.

Pin a large fresh female grasshopper to the bottom of a dissecting pan with the dorsal side up. With your fine scissors cut through the body wall at the right side of the middle line of the abdomen and thorax and pin out so as to expose the internal organs.

1. *The Circulatory System.*

(*a*) Look for the heart, which is a tube lying just beneath the dorsal surface.

(*b*) Do you find a system of tubules like that in man?

(*c*) What fills up the spaces in the body?

(*d*) Is the circulatory system closed or open? What is the course of the blood flow?

2. *The Respiratory System.*

(*a*) Look for white branching tubes, the tracheæ, which lead from the spiracles to all parts of the body.

(*b*) Examine a piece of a trachea under the microscope and draw.

(*c*) Along the sides of the abdomen are small white sacs, the air sacs.

(*d*) What are the functions of the tracheæ and air sacs?

(*e*) Discuss in your notes the relation between the circulatory system and respiratory system in the grasshopper and in man.

3. *The Reproductive System.*

(*a*) Find the rows of yellow eggs on either side of the abdomen.

(*b*) About how many eggs in your specimen?

(*c*) How do the eggs reach the outside of the body?

(*d*) How are they deposited?

(*e*) If one grasshopper lays so many eggs, why are there not more grasshoppers in the world?

4. *The Digestive System.*

(*a*) What kind of food is eaten, judging by the structure of the mouth parts?

(*b*) Where is the mouth?

(*c*) Find the tube leading from the mouth to the crop, the esophagus. Function?

(*d*) What is the function of the crop?

(*e*) The salivary glands are grapelike clusters near the crop. Function?

(*f*) Just back of the crop are the small fingerlike gastric cæca. Number? Function?

(*g*) The stomach lies behind the gastric cæca.

(*h*) The beginning of the intestine may be determined by the presence of long, thin tubes, the Malpighian tubes, attached to it. What is the function of these tubes?

(*i*) Make an outline of the side of a grasshopper, including the heart and the digestive system.

5. *The Nervous System.*

(*a*) Remove the digestive system by cutting through the esophagus and look for a whitish cord lying along the median line on the floor of the body cavity.

(*b*) Is this cord single or double?

(*c*) Are there enlargements in it? How many? Where?

(*d*) Open the brain case and note the nerves connecting with this cord beneath the esophagus.

(*e*) Look for the nerves passing to the legs, wings, eyes, and antennæ.

### *D.* Metamorphosis.

Collect as many stages in the growth of the grasshopper as possible; arrange them in a series beginning with the youngest and ending with the adult; and study the changes that take place during the life of an individual.

## INSECT ADAPTATIONS

### *A.* Locomotion.

1. *Wings.*

(*a*) Make an examination of the wings of the insects in your collection and select a bee or wasp, a butterfly or moth, and a beetle for study.

(*b*) *The bee or wasp.* How many wings? Color? Where attached? Leathery or membranous? Flat or folded? Is there a covering of hairs or scales? Are the fore wings fastened to the hind wings with hooklets? Make an outline of one of the fore wings, showing the venation.

(*c*) *Butterfly or moth.* How many wings? Color? Where attached? Is there a covering of hairs or scales? Rub off a few scales and draw several much enlarged. How are the scales arranged on the wings? Is the color in the scales or in the wings?

(*d*) *A beetle.* How many wings? Describe the fore wings. What are their functions? How used in flight? Are the hind wings folded or flat when at rest? How used in flight?

(*e*) If possible a flea, silver fish, or bedbug should be examined as an example of a wingless insect. Why do these insects need no wings? What is their method of locomotion?

2. *Legs.*

(*a*) Examine the legs of the insects in your collection and select a swimming insect like the water beetle, a dig-

ging insect like the mole cricket or young cicada, a running insect like the cockroach or tiger beetle, and a leaping insect like the grasshopper, for further study.

(*b*) A swimming insect. How are the legs modified for swimming? Describe their positions during their forward and backward movements through the water. Draw one.

(*c*) A digging insect. Which legs are fitted for digging? Draw one.

(*d*) A running insect. What is the shape of the legs? Draw one.

(*e*) A leaping insect. Which legs are adapted for leaping? Draw one.

### *B.* Respiration.

Collect some young aquatic insects such as the may fly, damsel fly, or stone fly.

(*a*) The may-fly nymphs possess tracheal gills on the sides of the abdomen. How many? Arrangement? Shape? Function?

(*b*) The damsel-fly nymphs are provided with leaflike gills at the end of the abdomen. Number? Shape?

(*c*) The stone-fly nymphs have tufts of gills just back of each leg. Number? Shape?

(*d*) Draw one gill of each kind.

### *C.* Securing Food.

#### 1. *Mouth Parts.*

The mouth parts of insects are fitted for biting, sucking, or lapping.

(*a*) Biting mouth parts. Compare the mouth parts of a beetle and a dragon fly with those of the grasshopper.

What kind of food does each feed upon? How is this indicated by the mouth parts?

(*b*) Sucking mouth parts of a squash bug or cicada. Note the sheath formed by the labium. Slit open the sheath and examine the four slender piercing organs within. These are the two mandibles and two maxillæ. What are the functions of the various parts? What is the food of sucking insects? Draw a mandible and a maxilla.

(*c*) Sucking mouth parts of a butterfly or moth. Note the long coiled tube underneath the head. This is the proboscis or sucking organ. How many parts? How are these parts arranged? How is the proboscis used?

2. *Legs.*

Carefully remove one of each pair of legs of the honey-bee.

(*a*) The prothoracic leg. Find the following structures and determine the function of each. Branched hairs on the coxa. Pollen brush at the end of the tibia. Velum at the end of the tibia. Antenna cleaner in the metatarsus. Eye brush on the metatarsus. Draw.

(*b*) Mesothoracic leg. Find the following structures and determine the function of each. Pollen brush at the end of the tibia. Pollen spur at the end of the tibia. Draw.

(*c*) Metathoracic leg. Find the following structures and determine the function of each. Pollen basket in the side of the tibia. Wax pinchers at the end of the tibia. Pollen combs on the side of the metatarsus. Draw.

### *D.* Concealment.

Compare the colors of the insects you capture with those of surrounding vegetation. Do they resemble those of the vegetation? Of what advantage is this to the insect? Give a list of five insects and describe the colors of each as compared with those of its natural surroundings.

## INSECTS INJURIOUS TO VEGETATION

Select from your collection the insects that feed upon vegetation, and separate them into two groups; placing in one all those with biting mouth parts and in another those with sucking mouth parts.

**Insects with biting mouth parts** chew up leaves and actually take the pieces into the digestive system. These insects may be poisoned by spraying the leaves of their food plants with a poison such as paris green. A mixture of one pound of paris green, two pounds of quicklime, and from one hundred to three hundred gallons of water is an effective insecticide for biting insects such as caterpillars and potato beetles.

**Insects with sucking mouth parts** cannot be destroyed by spraying poisons upon their food. Why? They, as well as biting insects, may be destroyed by contact insecticides. These are sprayed upon the insects and suffocate them. A commonly used contact insecticide is called kerosene emulsion. It is made up as follows: One half pound of soap is dissolved in one gallon of boiling soft water. This is poured into two gallons of kerosene and churned with a force pump until it looks like buttermilk. Dilute before using with ten to twenty parts of water.

1. *San José Scale.* Examine a leaf, twig, or fruit upon which are San José scales.

(*a*) Draw scales natural size and much enlarged.

(*b*) Turn over a large scale and examine the scale in-

sect beneath. What kind of mouth parts does it possess? Has it a thick exoskeleton? How is it protected? Draw.

(*c*) How may scale insects be destroyed?

2. *Plant Lice or Aphids.* Examine a plant louse under the microscope.

(*a*) Is it a biting or sucking insect?

(*b*) Are wings present?

(*c*) Is it fixed or able to move about?

(*d*) Note the honey tubes on either side of the body near the posterior end.

(*e*) Draw side view.

3. *A Caterpillar.* Select a caterpillar for examination.

(*a*) What are the principal parts of the body?

(*b*) Where are the spiracles and how many are there?

(*c*) Are the legs all alike? How many of each kind? Where located? What enables the caterpillar to cling to a leaf?

(*d*) What kind of eyes are present? How many?

(*e*) Are the mouth parts adapted for biting or sucking?

(*f*) How may caterpillars be destroyed?

## THE HOUSE FLY

The house fly is particularly important because of the fact that it distributes disease germs and is thus responsible for many cases of typhoid fever, tuberculosis, etc.

1. *The Head.*

(*a*) Note the shape of the antennæ. Function?

(*b*) Where are the compound and simple eyes located?

2. *The Mouth Parts.*

(*a*) Straighten out the proboscis and examine with the microscope. The proboscis is the labium.

(*b*) Is it smooth or rough at the end?

(*c*) Is it adapted for biting, sucking, or lapping?

(*d*) What part does it play in distributing disease germs?

(*e*) Draw the proboscis.

3. *The Wings.*

(*a*) How many wings?

(*b*) Where located?

(*c*) Are they smooth?

(*d*) The second pair of wings are knoblike and are called balancers.

4. *The Legs.*

(*a*) How many?

(*b*) Are they all alike?

(*c*) What structures on them enable the fly to walk on the ceiling?

(*d*) Are there hairs or bristles on them?

(*e*) What part do they play in distributing disease germs?

(*f*) Draw a leg.

## THE MOSQUITO

1. *The Eggs.*

(*a*) The eggs of mosquitoes may be found during warm weather on the surface of small ponds or puddles of water where the wigglers occur. They are usually laid in groups, but the anopheles mosquito lays its eggs singly.

(*b*) Draw a single egg.

2. *The Larvæ (Wigglers).*

(*a*) Examine living wigglers in a bottle of water or in a glass aquarium. What is their position while at the surface?

(*b*) Do your specimens belong to the anopheles or culex mosquito?

(*c*) Why do they frequent the surface?

(*d*) Where are the respiratory tubes in relation to the surface?

(*e*) How do the wigglers reach the surface?

(*f*) How do they get to the bottom?

(*g*) Place a goldfish in the aquarium. Does it eat the wigglers? How many? How can a pond be rid of mosquitoes?

(*h*) Place a few drops of kerosene on the surface of the water. What effect does it have upon the wigglers, or pupæ and adults that may be present?

3. *The Pupa.*

(*a*) Place some wigglers in an aquarium and cover the top with cheesecloth. They will soon change to pupæ.

(*b*) How do these differ from the wigglers?

4. *The Adult.*

(*a*) Examine the mouth parts, wings, and legs.

(*b*) Are the mouth parts for sucking or biting?

(*c*) On what does the mosquito feed?

(*d*) What relation has its feeding habits to the distribution of disease germs?

## THE CLASSIFICATION OF INSECTS

### *A.* Orders of Insects.

Insects are animals whose bodies are divided up into segments. These segments are grouped together into three main divisions, — the head, thorax, and abdomen. The head bears one pair of antennæ and the thorax bears three pairs of jointed legs, and the abdomen is without legs. The insects are separated into orders according to the kind of wings and mouth parts they possess, and the kind of metamorphosis they pass through before reaching the adult stage.

### B. Classification.

Examine a number of insects selected by your teacher in the following way. With the help of the description in your textbook place each in its proper order and tell why.

1. *Wings.*

Number? Shape? Are fore and hind wings equal in size and similar in shape? Are they alike in thickness? Membranous, thick, or coated with hairs or scales? Are they flat or folded when at rest?

2. *Mouth Parts.*

Are they adapted for biting, sucking, or lapping, or for any two of these processes?

3. *Metamorphosis.*

Only when the complete life history is known can you determine by original observation the kind of metamorphosis passed through by your specimens. Is the metamorphosis direct or indirect? What name is commonly applied to the larva?

## THE SPIDER

I. *FIELD STUDIES.*

1. *Look for spider's webs* in the grass and bushes and in the corners of rooms in the house.

2. *Tear down a web* and watch the spiders build a new one.

(*a*) Is it built in the same place?

(*b*) How long does it take to build a new one?

(*c*) What kinds of insects are captured?

(*d*) How does the spider act when an insect alights on the web?

3. *Look on trees*, bushes, weeds, flowers, etc., for spiders without webs.

(*a*) How do these kinds capture their food?

(*b*) Do they remain in one place?

4. *Look for cocoons* containing eggs or young spiders.

5. *Collect* as many spiders as you can find, placing them in the bottles filled with 70 % alcohol.

II. *LABORATORY STUDIES.*

1. *The Cephalothorax.*

The head and thorax of the spider are united into a head-thorax (cephalothorax).

(*a*) Are there any antennæ? How many?

(*b*) Are there compound eyes? Where located? Shape? Color? Function?

(*c*) What is the number and shape of the jaws? Are the mouth parts for biting or sucking? Is a second pair of jaws present?

(*d*) How many legs are there? How are they arranged? Do they bear claws? How many? Function?

2. *The Abdomen.*

(*a*) Is the abdomen segmented? How many segments?

(*b*) Examine the spinnerets on the ventral surface near posterior end. How many? Function?

(*c*) The lung sacs are on the ventral surface near the anterior end. How many? Function?

(*d*) Note the tracheæ just in front of the spinnerets. How many? Function?

3. *Comparison with Insects.*

(*a*) How can you distinguish between an insect and a spider from an examination of the legs and antennæ?

(*b*) How do the head and thorax of the spider differ in their relations from those of the insect?

(*c*) What structures are present on the abdomen of the spider and not in the insect?

## MYRIAPODS

I. *FIELD STUDIES.*

(*a*) Myriapods may be found under stones, boards, and the bark of logs.

(*b*) What do they do when they are uncovered? Do they shun the light?

II. *LABORATORY STUDIES.*

1. *The Body.*

(*a*) What are the principal parts of the body?

(*b*) Is the body segmented?

2. *The Legs.*

(*a*) How many legs are there?

(*b*) Are they all alike?

(*c*) How are they arranged?

3. *The Head.*

(*a*) Are antennæ present? How many?

(*b*) Are eyes present? What kind? How many? Where are they located?

(*c*) Are the mouth parts fitted for biting or sucking? What do myriapods eat?

(*d*) Compare a centipede with a millipede. What differences do you find?

## THE CRAYFISH

I. *FIELD STUDIES.*

(*a*) Crayfishes may be found in streams, ponds, or small lakes, usually hiding under a small stone.

(*b*) Why do they conceal themselves in this way?

(*c*) If one is disturbed, how does it attempt to escape?

(*d*) How does it become aware of the presence of an enemy, by sight or by means of its antennæ?

(*e*) Are crayfishes found alone or in groups?

(*f*) Look for specimens with eggs attached to the appendages underneath the tail.

(*g*) Do you find any soft-shelled individuals? What causes this condition?

II. *LABORATORY STUDIES.*

### *A.* Activities of the Living Crayfish.

Crayfishes should be brought into the laboratory, where they may be kept in tanks or aquaria.

(*a*) Do they prefer light or shady places?

(*b*) How do they conceal themselves?

(*c*) What are the two methods of locomotion? Describe.

(*d*) How do they defend themselves? Are their pinchers used in walking?

(*e*) Feed them with pieces of meat and vegetables. Are they carnivorous, herbivorous, or omnivorous?

(*f*) Can they hear?

(*g*) Can they smell?

(*h*) The gills which lie in a chamber beneath the exoskeleton on either side of the thorax are bathed by a stream of water that passes through the chamber.

(*i*) Put a little ink in the water near the edge of the thorax. In what direction does the current of water flow?

**B. External Features.**

1. *Protective Covering.*

Compare the exoskeleton of the crayfish with that of the grasshopper.

2. *Divisions of the Body.*

(*a*) The body consists of a cephalothorax and an abdomen. The cephalothorax comprises the head and thorax combined.

(*b*) Is the body segmented? How many segments in the abdomen? In the thorax? In the head?

3. *The Cephalothorax.*

(*a*) A cervical groove separates the exoskeleton of the head from that of the thorax. This exoskeleton is called the carapace.

(*b*) Is it attached to the body at the sides of the thorax? Can you find cavities beneath it? What do these cavities contain?

(*c*) *The eyes.* How many? Where located? Are they simple or compound? Can they be moved? How is movement possible? What are the advantages of this power of movement?

(*d*) *The antennæ.* These appendages possess each one long-jointed filament. How many? Where located? Can they be moved about? What is their function? Remove and draw.

(*e*) *The antennules.* These appendages possess each two short-jointed filaments. Remove one of them and compare it with an antenna.

(*f*) Because of the overlapping positions of the mouth parts and the other appendages it is best to start at the posterior end of the abdomen and carefully pull off the appendages on one side, arranging them in order on a drawing card or in a dissecting tray. Then beginning with those removed from the head it is a simple matter to identify and compare these various appendages.

(*g*) *The jaws.* These two hard-toothed appendages follow the antennæ. Note the jointed palp borne by each. In what direction do the jaws move? How is food kept between them?

(*h*) *The maxillæ.* These two pairs of appendages lie just back of the jaws. What is their function?

(*i*) *The maxillipeds.* Between the maxillæ and the pinchers are three pairs of appendages called maxillipeds. What is their function?

(*j*) *The legs.* How many pairs? What is the first pair usually called? How does it differ from the others? Is it used in walking? What is its function? Compare the second and third legs with the third and fourth.

4. *The Abdomen.*

(*a*) In what direction can the abdomen be moved?

(*b*) How is it used in swimming?

(*c*) *The abdominal appendages.* These are called swimmerets. How many are there? The third swimmeret is the simplest appendage on the crayfish. It possesses a basal part and two branches. At the end of the abdomen the last pair of appendages are much flattened. What is their function?

(*d*) Make a sketch of the third abdominal appendage. Then draw the last abdominal segment, the pinchers, and the second maxilla. All of the appendages were originally of the type of the third swimmeret, but have become modified in structure for the performance of various functions.

### C. Internal Organs.

1. *The Circulatory System.*

(*a*) Remove the dorsal wall of the abdomen and thorax. Just beneath the dorsal wall of the thorax is a whitish oblong body, the heart. It lies in the pericardial cavity.

(*b*) What is its function? Do you find any openings into it? How many? Where? What is their function?

(*c*) How many tubes are there? Where do they go?

(*d*) What is the course of the blood flow in the crayfish? How is the blood flow maintained?

(*e*) What are the functions of the blood?

2. *The Respiratory System.*

(*a*) Remove the side of the walls of the carapace, thus exposing the gill chambers.

(*b*) How many gills are there? To what are they attached? What is their function? What is their relation to the circulatory system?

(*c*) Remove a single gill, place it under water, and draw.

3. *The Digestive System.*

(*a*) Upon what sort of food does the crayfish live? How is it captured? In what way is it ground up by the mouth parts?

(*b*) Remove the dorsal wall of the head. Just beneath lies the stomach. Note the constriction which divides it into two portions, one anterior, the other posterior.

(*c*) Just back of the stomach are the reddish or brownish lobes of the liver. How many lobes? What is the function of the liver? How is it connected with the digestive system?

(*d*) The intestine passes from the stomach through the abdomen. Is it straight or coiled?

(*e*) Make a diagram of the entire digestive system and name all parts.

4. *The Muscular System.*

(*a*) Where are the principal muscles of the crayfish situated? Why are they distributed in this way?

(*b*) Cut open a pincher and examine the muscles within. How are the muscle fibers arranged in them?

(*c*) What are the general functions of muscles?

5. *The Nervous System.*

(*a*) The nervous system in the crayfish is similar in location and general structure to that of the grasshopper.

(*b*) Compare the two systems.

6. *The Excretory Organs.*

(*a*) Situated in the head beneath the stomach are two "green glands." These are organs of excretion which open in the bases of the antennæ.

(*b*) Why are excretory organs necessary?

(*c*) How are the waste substances removed?

7. *The Auditory Organs.*

(*a*) In the base of each antennule is an ear sac.

(*b*) Has it any contents?

(*c*) What is its function?

### *D.* Comparative Studies.

The crayfish belongs to the class Crustacea. Many kinds of Crustacea are abundant in fresh-water ponds and streams, and others may be found in damp places under boards or at the seashore. The general structure and physiology of all these are similar, but the details are very different. A collection of Crustacea may be made, followed by a study of the relations between the structure and functions of the various parts of the body.

## THE CLASSIFICATION OF THE ARTHROPODA

### *A.* The Similarities of the Members of the Phylum Arthropoda.

Select a number of different kinds of arthropods and answer the following questions concerning them:

(*a*) Is the body segmented or unsegmented?

(*b*) Is the body radially or bilaterally symmetrical?

(*c*) Is there an exoskeleton or an endoskeleton?

(*d*) What sort of exoskeleton do they possess?

(*e*) Are the appendages segmented or unsegmented?

(*f*) How are the appendages arranged on the segments?

*Conclusion.*

What are the general characteristics of all arthropods?

### *B.* The Separation of Arthropods into Classes.

Select a crayfish, a centipede, an insect, and a spider, and answer the following questions concerning each of them:

(*a*) What is its general shape?

(*b*) How many segments does it possess?

(*c*) How many and what are the chief divisions of the body?

(*d*) How many appendages are there and where are they located?

(*e*) Are there antennæ present? If so, how many?

(*f*) Are eyes present? Are they simple or compound? How many are there of each kind?

(*g*) Does it possess gills or tracheæ?

*Conclusion.*

Place each specimen in its proper class and tell why.

The classes of arthropods represented and their characteristics are as follows:

*Class Crustacea.* Arthropods that breathe by means of gills. They possess two pairs of antennæ. The head and thorax are often fused to form a cephalothorax.

*Class Myriapoda.* Arthropods that breathe by means of tracheæ. They possess one pair of antennæ. The head is distinct. Each segment bears one or two pairs of appendages.

*Class Insecta.* Arthropods that breathe by means of tracheæ. Insects have a single pair of antennæ. The body is divided into head, thorax, and abdomen. There are three pairs of legs and usually wings.

*Class Arachnida.* Arthropods that breathe by means of tracheæ or book lungs. No antennæ are present. The head and thorax are united to form a cephalothorax.

## THE FRESH-WATER MUSSEL OR CLAM

I. *FIELD STUDIES.*

(*a*) Mussels may be found in ponds or sluggish streams.

(*b*) Do they occur in shallow or deep water? On muddy or sandy bottoms?

(*c*) Do they lie on their sides or do they maintain an upright position?

(*d*) Are they stationary or moving about?

(*e*) Do they leave a trail behind them?

(*f*) Are the shells of dead mussels open or closed? Why?

(*g*) Can you pull open the valves of the shell? Why not?

II. *LABORATORY STUDIES.*

### *A.* The Activities of the Living Mussel.

(*a*) Living specimens should be placed in a pail of water and brought into the laboratory where they may be studied in a tank or in an aquarium having a few inches of sand in the bottom.

(*b*) What position does the mussel maintain? Lay a specimen on its side and describe its actions in righting itself.

(*c*) If a mussel that is moving is picked up, what activities of the foot and shell result?

(*d*) The posterior margin of the flaps of tissue (mantle) that protrude from the shell when the mussel is in its nor-

mal position on the bottom form two openings called the dorsal and ventral siphons. Insert a drop of ink in the water near the siphons and note the direction of currents that enter and pass out through these openings.

(*e*) How do mussels become aware of their surroundings? Touch the margin of the siphon. Is it sensitive to touch? Reflect light upon the siphons. What happens? What conclusion do you reach regarding its sensitiveness to light?

### *B.* External Features.

1. *The Shell.*

(*a*) What are the shape and color of the shell

(*b*) Of what use is the shell to the clam? What is its disadvantage?

(*c*) The concentric lines on the shell are lines of growth. Which is the oldest part of the shell? Can you tell the age of your specimen by the number of lines of growth?

(*d*) Between the valves, where they are hinged, is a hinge ligament. This is elastic and compressed. What do the ligaments do when the mussel dies and can no longer hold the valves together?

(*e*) Draw a side view of the mussel. The dorsal part of the shell is hinged; the ventral part is thin; the anterior end is blunter than the posterior.

(*f*) Cut the muscles which hold the valves of the shell together by inserting a knife between them, first in the anterior dorsal region and then in the posterior dorsal region.

(*g*) The inside of each valve of the shell is covered by a flap of tissue, the mantle. Push back the mantle. Where is it attached?

(*h*) What is the nature of the inner surface of the shell? Are any pearls present? How are pearls formed?

(*i*) How do the two shells fit into each other at the hinge?

(*j*) Where are the muscles that hold the valves together attached? Look for muscle scars.

(*k*) Draw the inside of a valve.

(*l*) Break a valve into pieces and note the three layers of which it is composed. The outer layer resists the action of acids in the water. Of what value is this to the mussel? What part of the body secretes the shell?

### C. Internal Organs.

Notice the softness of the body. Compare with the crayfish. How does the mussel escape being injured?

#### 1. *The Respiratory System.*

(*a*) On either side of the body are the gills which hang down into the mantle cavity. How many are there? If the outer gill is thicker than the inner one, it is probably filled with very young mussels.

(*b*) Cut off part of a gill of a living mussel, place it on a slide, and examine with the high power of the microscope. Insert a drop of ink under the cover glass. What causes the flow of water? Does this have any relation to the currents of water that pass through the siphons?

#### 2. *The Organ of Locomotion.*

(*a*) What is the shape of the foot? Of what is it composed? How is it forced out of the shell? How is it redrawn into the shell?

(*b*) How is the foot used in locomotion?

3. *The Digestive System.*

(*a*) The mouth is situated between the foot and the large anterior muscle, and lies between leaflike bodies called labial palps.

(*b*) How many palps are there? Examine a piece of one from a living mussel. In what way is it similar to the piece of gill? What is the function of the palps?

(*c*) The food of the mussel consists of very small particles that float about in the water. How is it drawn into the mantle cavity? How is it drawn into the mouth?

(*d*) The saclike stomach lies just back of the anterior muscle.

(*e*) The intestine coils about in the foot and then passes through the pericardium, which is a cavity just beneath the hinge, and just above the large posterior muscle.

(*f*) The digestive gland or liver lies in the dorsal part of the foot and surrounds the stomach. What is its function?

4. *The Circulatory Organs.*

(*a*) The heart lies in the pericardial cavity just beneath the hinge. It can be seen to pulsate in freshly opened specimens.

(*b*) The two parts of the heart are the muscular ventricle, surrounding the intestine, and the two thin-walled auricles just beneath it. Blood is forced by the ventricle through arteries which pass along the intestine both anteriorly and posteriorly. After circulating through the gills, mantle lobes, and other parts of the body it reaches the auricles and is drawn from them into the ventricle by suction following the contraction of the ventricle.

(*c*) What changes take place in the blood in the gills? In the mantle lobes? When it comes in contact with the digestive system?

5. *The Excretory Organs.*

(*a*) The kidneys lie just beneath the heart. What is their function?

(*b*) What changes take place in the blood that passes through them?

6. *The Nervous System.*

(*a*) There are three large pairs of masses of nervous tissue in the mussel, but they are rather difficult to find.

(*b*) Look for the pair that corresponds to the brain in other animals on either side near the mouth.

(*c*) The visceral ganglia lie just beneath the large posterior muscle and are easily seen.

(*d*) The pedal ganglia are embedded in the foot. All three pairs of ganglia are connected by nerve cords.

## THE SNAIL

### General Observations.

(*a*) The snails most easily collected are those that live in fresh-water ponds or streams. Here will be found the small, thin-shelled *Physa*, the flat-shelled *Planorbis*, and the long, slender-shelled *Lymnea*.

(*b*) Place a number of snails in an aquarium and study their habits. Do they come to the surface? How do they get there? What do they do when they reach the surface? Do snails breathe with gills? How do they get air?

(*c*) Compare the foot of the snail with that of the mussel. How do snails move? Place one in a flat dish and allow it to move about; then add some powdered chalk to the water. The chalk will stick to the lines of slime formed by the snails.

(*d*) What does the snail eat? Does it prefer one sort of food to another? Does it possess a sense of taste?

(*e*) How many tentacles has it? Are they all alike? Try to find out what they are used for.

(*f*) Are eyes present? Where? Why is this location of advantage to the snail?

(*g*) Make a sketch of a creeping snail and name all the visible parts.

## THE EARTHWORM

### *A.* Activities of the Living Earthworm.

(*a*) Earthworms may be collected by digging during the daytime, or, since they come up out of their holes at night, they may be easily gathered then with the aid of a lantern, especially after a rain.

(*b*) How deep in the ground do the earthworms stay during the day? Of what advantage to them is the habit of coming out of their burrows after dark?

(*c*) Where do the earthworms come from that appear in the daytime after a heavy rain? Do they "rain down" or up?

(*d*) In what kind of soil do you find the most worms? Why?

(*e*) Examine an area of good black soil in the morning after a damp night. Do you find little heaps of black earth upon it? How did they get there? Are the openings of some of the burrows filled with leaves and grass?

(*f*) Upon what does the earthworm feed? How does it obtain its food?

(*g*) Locomotion. Place an earthworm on a damp piece of paper and study its method of locomotion. Describe.

(*h*) Try to extract an earthworm from its burrow. What enables it to cling fast? Run your fingers over an earthworm from the head toward the tail and then from the tail toward the head. What difference do you note? What causes the rough feeling? Do the bristles play a part in locomotion or in clinging to the burrow?

(*i*) Watch an earthworm burrow into the ground and describe the method.

(*j*) Sensitiveness. What does an earthworm do when light is reflected upon it at night? Does it shun the light? Why does it remain in its burrow during the day? The earthworm has no eyes, but the surface of the body is sensitive to light.

(*k*) Find out by touching an earthworm in various places which part of the body is most sensitive to touch.

(*l*) Examine the median dorsal region and notice the pulsations of the reddish artery just beneath the skin.

### *B.* External Features.

(*a*) Note the shape of the body. What relation has this shape to the habits of the animals?

(*b*) The body is divided into many similar parts called segments, somites, or metameres. How many segments are there? Does every worm have the same number?

(*c*) Near the anterior end is a swollen region called the girdle or clitellum. How many segments does it comprise? Counting from the anterior end does the clitellum always comprise the same segments? What is its function?

(*d*) Examine a segment with a lens and determine the number and position of the bristles or setæ.

(*e*) Find as many of the following openings as possible:

(1) The mouth at the anterior end.

(2) The anus or vent at the posterior end.

(3) The openings of the reproductive organs in segments 9–15.

(4) Excretory pores near the bristles in each segment.

(5) Dorsal pores in the mid-dorsal region of each segment.

(*f*) Is the skin naked or covered? Examine a very small piece of the outer covering (the cuticle) under high magnification and note the lines and small pores.

**C. Internal Organs.**

1. *The Body Cavity.*

(*a*) Carefully make an incision through the body wall along the entire length of an earthworm in the median dorsal line. Spread out the body wall and pin it down in a dissecting pan under water.

(*b*) The internal organs lie in a body cavity called the cœlom. Is the body cavity single or divided into compartments? Does an internal compartment coincide with each external segment? The partitions between the compartments are called septa.

2. *The Circulatory System.*

(*a*) The dorsal blood vessel has been noted in the living worm. It lies just beneath the dorsal body wall along the median line. What is the direction of the blood flow in it? Is it contractile?

(*b*) In segments 6–10 enlarged branches of the dorsal vessel extend around the alimentary canal. How many are there? Why are they called "hearts"?

(*c*) Push the alimentary canal to one side and find the ventral blood vessel.

3. *Digestive System.*

(*a*) Identify the parts of the alimentary canal as follows beginning at the anterior end:

(1) Mouth.

(2) Pharynx. Note the muscular attachments to the body wall. What is its function?

(3) The esophagus.

(4) The crop. Are the walls thin or thick? What is its function?

(5) The gizzard. Are its walls thick or thin? What is its function?

(6) The intestine. Is it straight or pouched?

(*b*) Draw in outline the body of the earthworm, showing the alimentary canal as seen from the side.

4. *The Respiratory System.*

(*a*) Do you find any gills or air tubes?

(*b*) In the earthworm respiration takes place through the general surface of the body. Many blood vessels lie in the skin and the exchange of gases is carried on through the moist surface of the body.

5. *The Excretory System.*

(*a*) In each segment of the body cavity are two coiled tubes, one on either side of the alimentary canal. These are excretory organs, called nephridia.

(*b*) Where is the opening into the body cavity?

(*c*) Where is the opening to the outside?

(*d*) What is their function?

6. *The Nervous System.*

(*a*) Above the pharynx lies the brain or cerebral ganglia. The brain is connected with the ventral nerve cord by nerve threads passing around the pharynx.

(*b*) Trace the ventral nerve cord throughout the length of the body. Is it single or double? How many ganglia are there? Where are they located?

7. *The Reproductive System.*

The reproductive system in the earthworm is very complex and difficult to make out. The reproductive organs lie in segments 9–15 and are whitish in color.

8. *Study of a Cross Section through the Body.*

(*a*) Examine a prepared section of an earthworm and identify the following :

(1) Coelom.
(2) Intestine. Hanging down into the intestine is a fold called the typhlosole. What is its function?
(3) The dorsal blood vessel.
(4) The ventral blood vessel.
(5) The nerve cord.
(6) Nephridia.

(*b*) Note the following layers in the body wall :

(1) Cuticle.
(2) Epidermis.
(3) Circular muscles. Function?
(4) Longitudinal muscles. Function?

## HYDRA

### *A.* The Activities of a Living Specimen.

(*a*) Hydra may be found attached to water plants in ponds or quiet streams. Bring a lot of pond weeds into the laboratory; place them in a large glass dish, and look for the animals as they extend out into the water.

(*b*) How many tentacles are there? How do they compare in thickness with the body?

(*c*) Touch an extended animal with a needle. What does it do? Is this sensitiveness to touch of benefit to the animal? Why? What can you say of the shape of the body? Is the body contractile and extensile? What sort of tissue is specialized for contractile purposes?

(*d*) Watch to see if your specimen moves. If it does, describe the method. Distinguish between motion and locomotion. How does Hydra move from place to place?

(*e*) Place a very small piece of fresh meat within the circlet of tentacles. If the animal is hungry, it will seize it with its tentacles and force it into the mouth. Describe the process.

### *B.* The Anatomy of Hydra.

(*a*) Examine a specimen under the microscope and note that the body is a hollow tube which is in communication with the hollow tentacles.

(*b*) Is the animal asymmetrical, radially symmetrical, or bilaterally symmetrical?

(*c*) How many tentacles are there? Is the number constant in different specimens?

(*d*) Notice the little protuberances on the tentacles and body. These are caused by the presence of stinging cells called nematocysts. A little acetic acid placed near them will cause them to explode. What are their functions?

**C. The Reproduction of Hydra.**

(*a*) Reproduction is both sexual and asexual. Large conical projections *may* be found near the tentacles; these are called spermaries and contain sperm cells. Near the base of the body other globular projections *may* be found which contain eggs.

(*b*) Budding is a very common method of multiplication. Look for specimens that bear small hydralike buds. The buds soon break away from the parent and lead a separate existence.

(*c*) Draw a budding Hydra.

(*d*) Draw a Hydra showing spermaries and eggs if you find one in the right condition.

## CORAL

(*a*) The best coral for purposes of study is known as *Astrangia*. It may be found attached to rocks along our eastern seacoast.

(*b*) Note the similarity between the body and tentacles of the coral and of Hydra. What is the symmetry? How many tentacles?

(*c*) Remove the body (polyp) and examine the skeleton. Observe the calcareous septa. How many are there? Place a piece of skeleton in some hydrochloric acid. Describe what happens. Of what substance is the skeleton composed?

(*d*) Draw an expanded coral polyp.

(*e*) Draw the cup in which the polyp stood.

## THE BATH SPONGE

(*a*) The ordinary bath sponge is the skeleton of an animal that lives in the sea. The cavities were filled up by the body of the animal when it was alive.

(*b*) Take a few fibers from the sponge; examine under the compound microscope and draw.

Pond weeds should be brought into the laboratory, placed in shallow glass dishes, and covered with water. After the water has stood in a warm place for a week or two, the scum which forms on the surface will be found to contain many kinds of Protozoa.

### *A.* Ameba.

(*a*) Ameba is almost colorless and so small that it is difficult to find. Place a little scum on a slide and examine it with most of the light shut off.

(*b*) What shape is the animal? Is the shape constant or does it change?

(*c*) Is it stationary or does it move about? Describe its movements.

(*d*) Notice that the outer part of the body, the ectosarc, is clear, whereas that within, the endosarc, is granular.

(*e*) Within the endosarc is a spherical, granular body, the nucleus. If you cannot see it in your animal, have your teacher point it out to you in a stained specimen.

(*f*) Draw six outlines of your specimen showing six successive conditions during locomotion.

### *B.* Paramecium.

(*a*) The slipper animalcule usually occurs in abundance in the dishes of decaying pond weeds. They are visible to the naked eye if a black background is used, but should be examined on a slide with the compound microscope.

(*b*) What is the shape of the body? Is it constant or changing? Can you distinguish anterior and posterior ends?

(*c*) How does it move about? Can you see threadlike projections from the body? These are cilia. How do they aid the animal in swimming?

(*d*) Examine carefully a specimen that has become quiet. Notice the thin cuticle surrounding the body. Has this any effect upon the constancy of shape of the animal?

(*e*) On one side near the forward end is a groove at the posterior end of which is the mouth opening. Food particles in the water are driven into the mouth by the cilia. Look for this process.

(*f*) Near the middle of the body is the large granular nucleus. This may be seen more clearly in stained specimens.

(*g*) The clear spaces in the body are called vacuoles. Some of these are permanent, some contain food particles and are called food vacuoles, and two of them are called contractile vacuoles.

(*h*) The contractile vacuoles lie one near each end of the body. Watch them and see them contract. Their contents are forced to the outside. They then fill up again. They are excretory in function, and force waste products out of the body. Do they both contract at the same time? How often do they contract?

(*i*) Look for specimens that have a constriction in the middle. These are dividing into two. This process is called binary division and is a method of asexual reproduction.

(*j*) Sometimes two specimens will be found fastened together side by side. They are said to be conjugating. During this process part of the nucleus of each passes over into the other. Then the two animals separate. Conjugation is followed by a series of binary divisions.

## THE FROG

The common frog is more nearly like man in structure and physiology than any other animal that may easily be obtained for study in the laboratory.

### *A.* The Movements of the Frog.

(*a*) Notice the normal resting position of the frog, especially the peculiar attitudes of the fore and hind limbs. What is the significance of this attitude?

(*b*) Cause a frog to leap. How is this movement effected?

(*c*) Place a frog in deep water and note how the legs are employed in swimming.

(*d*) Note the attitude of the frog when resting at the surface in deep water. Warming the water will bring it to the surface.

(*e*) When the frog is alarmed in this position, it will dive quickly to the bottom. Try to make out how the diving is accomplished.

(*f*) Take a frog in your hands and note that the body swells on account of the air that is forced into it.

(*g*) Note the movements that occur during croaking. Place the head of a croaking frog under water, and it will be seen that air is forced back and forth between throat and lungs, while little or none escapes to the outside.

(*h*) Study the respiratory movements of the frog. How

is air taken into and expelled from the body? The frog is devoid of ribs and is unable to enlarge the cavity of the body directly; it has recourse, therefore, to an indirect method for filling the lungs which can be made out by carefully observing the movements of the throat, nares (nostrils), and the body. The glottis through which air passes from the throat into the lungs may be opened and closed as occasion demands.

(*i*) In the eyes note the colored iris, the oblong pupil, the short upper eyelid, and the nictitating membrane which acts as a lower eyelid.

(*j*) Cause the eye to close by pressing it with the finger. Note that the eye can be pressed into and protruded from the head. Note that withdrawal of the eye is accomplished by closure of the lids.

(*k*) Rotate a frog in a horizontal plane. Note that the head turns opposite the direction of the movement; often the body also turns about in the same way.

(*l*) Rotate the frog back and forth about a horizontal axis and note that the head is moved up and down contrary to the direction of rotation. These movements are called compensatory motions, and they serve to maintain a fixed position in space.

(*m*) Frogs may be thrown into a so-called state of hypnotism as follows: Seize a frog firmly in the hands and lay it on its back, holding it so as to prevent its struggles. After it has been quiet for a few minutes remove your hands very slowly, then the frog will often lie a long time in an immobile condition. It can usually be brought out of this state by a sudden jar.

(*n*) Frogs have a tendency to place their bodies so as to face the light. Place a frog in a glass dish near a window and note result.

**B. External Features.**

(*a*) Observe carefully the colors of the upper side and under side of the body.

(*b*) Besides mucus, the skin of the frog secretes a small amount of a whitish, acrid fluid, when irritated. In the toad the glands secreting this acrid fluid are very well developed glandular elevations.

(*c*) The tympanic membrane of the ear lies a short distance behind the eyes.

(*d*) The brow spot is a small, light spot midway between the anterior ends of the eyes.

(*e*) The mouth.

(*f*) The anus (opening of the cloaca).

(*g*) The anterior nares, or external openings of the nasal cavities.

(*h*) The fore limbs. There are three divisions: arm, forearm, and hand. In the male there is a thickening along the inner edge of the first digit which is especially prominent in the breeding season.

(*i*) The hind limbs. Three divisions are present: thigh, leg, and foot. What function has the web?

**C. The Mouth Cavity.**

Open the mouth of a recently killed frog to its widest extent and note the following:

(*a*) The teeth. Where are they located? What is their shape? What is their function?

(*b*) The posterior nares or internal openings of the olfactory sacs.

(*c*) The Eustachian tubes at the sides of the posterior part of the roof. Where do they lead?

(*d*) A pair of rounded prominences in front of the Eustachian tubes. How are they caused?

(*e*) The tongue. What is its shape? Where is it attached?

(*f*) The glottis is a longitudinal slitlike opening on the summit of a prominence on the posterior part of the floor. Where does it lead?

(*g*) In the male, the openings of the vocal sacs just beneath the angle of the mouth.

### *D.* General Internal Anatomy.

(*a*) Divide the skin in the ventral middle line, from the posterior end of the body to the angle of the jaw.

(*b*) How and where on the ventral surface is the skin attached?

(*c*) Note the great lymph spaces beneath the skin between the attachments.

(*d*) Note (by feeling) the cross-shaped pectoral girdle, the center of which lies in the line uniting the bases of the two arms. The longitudinal bar of the cross is the sternum.

(*e*) Make a longitudinal incision through the ventral body wall, a little to the right of the midline and extending forward through the pectoral girdle to the level of a line joining the angles of the jaws.

(*f*) Under the sternum, which can be raised, is a membranous sac, the pericardium, containing the heart.

(*g*) Pin back the body walls so as to expose the viscera, after carefully freeing the sternum from the pericardium. Find the following organs.

(*h*) The liver. Find the gall bladder.

(*i*) The lungs. These are two thin-walled sacs at the side of and above the heart.

(*j*) The fat bodies. These are yellow tufts of flattened

processes attached to the dorsal wall or the body cavity just anterior to the reproductive organs.

(*k*) The stomach. This is large and whitish. It turns to the left at the level of the liver and again to the right where it merges into

(*l*) The small intestine, and finally

(*m*) The large intestine. Note, if the animal has not been dead too long, the peristaltic movements of these organs. What is the function of these movements?

(*n*) The mesentery is a thin membrane uniting the coils of the intestine.

(*o*) The pancreas. Turn the liver forward, and the pancreas will be seen as an elongated, light yellow organ stretching between the liver and the first part of the small intestine.

(*p*) The spleen. Displace the anterior end of the stomach and the spleen will be seen between it and the anterior end of the large intestine, as a small, dark-colored, roundish organ lying in the mesentery.

(*q*) The bladder is a bilobed sac with delicate walls lying in the posterior angle of the body cavity.

(*r*) The reproductive organs attached to the dorsal body wall behind the fat bodies.

(*s*) The oviducts in the female are coiled tubes lying along the length of the sides of the body cavity. They are large in the breeding season. How are they attached?

(*t*) The kidneys are reddish, flat bodies attached to the dorsal body wall.

### *E.* The Internal Organs.

1. *The Digestive System.*

(*a*) The mouth opens into the œsophagus. This is a

short, wide tube, very distensible, leading from the mouth cavity to the stomach.

(*b*) The stomach. What is its position and shape? Notice the constriction near the posterior end. What is its function?

(*c*) Slit open the stomach along its left side from one end to the other. Wash out its contents, and examine the interior. Examine the cut edge with a lens and note three chief layers.

(1) The inner mucous layer (mucosa) thrown into folds.
(2) The spongy sub-mucosa following these folds.
(3) The tough muscular layer. A fourth very thin layer composed of peritoneum covers the outer surface of the muscular layer.

(*d*) The duodenum is the first portion of the small intestine lying parallel to the stomach and extending forward. It receives the secretions of the liver and pancreas.

(*e*) The small intestine proper. Under cover of the liver the duodenum turns abruptly backward, and after a number of coils the small intestine passes abruptly into

(*f*) The large intestine.

(*g*) The cloaca is the last portion of the alimentary canal. Into it open the ducts from the kidneys, bladder, and reproductive organs. It opens to the exterior by the anus.

(*h*) The liver.

(1) How many lobes? How arranged?
(2) Are the lobes united by liver tissue or only by ligaments? Notice the ligaments which unite the liver to the stomach and duodenum.

(3) Note the gall bladder and the bile duct with the various liver ducts that enter it from the lobes of the liver.

(4) Trace the common bile duct to its termination in the duodenum.

(*i*) The pancreas. Its ducts empty into the common bile duct. Both liver and pancreas are glands which pour their secretions into the intestine.

(*j*) Make a drawing of the alimentary canal, including in it the liver and pancreas.

2. *The Respiratory System.*

(*a*) The nasal openings, glottis, and lungs have already been noted.

(*b*) Find the trachea and notice that it sends a branch to each lung.

(*c*) Make an outline of the respiratory organs and name all parts.

3. *The Excretory System.*

(*a*) Cut the large intestine across near the cloaca and dissect it freely as far forward as the anterior end of the kidneys. If your specimen is a female, remove the ovary from one side.

(*b*) The kidneys. Describe the form and general appearance of the kidneys. Note the yellowish adrenal bodies on the ventral side of the kidney. These correspond to the suprarenal bodies of man.

(*c*) The ureters are white tubes which start from the outer edge of the posterior quarter of the kidneys.

(*d*) The bladder is slightly bilobed, heart-shaped, opening by its narrow neck on the ventral wall of the cloaca.

4. *The Reproductive System.*

The Female Reproductive System.

(*a*) Ovaries. The size of the ovaries is very variable. Just before the breeding season they are very large, but after egg laying they become very much reduced.

(*b*) The oviducts are two much-convoluted tubes lying in the body cavity on the right and left of the median line. In the breeding season the walls become thick and glandular, and furnish the jelly in which the eggs are laid. Each oviduct opens into the anterior end of the body cavity; posteriorly it passes into a thin-walled distensible section known as the uterus.

The Male Reproductive System.

(*a*) The two testes are a pair of yellowish bodies just below the kidneys.

(*b*) The sperm cells that arise in the testes pass through a number of delicate tubes into the kidney, then into the ureters, and finally outside by way of the cloaca. When the eggs are laid by the female, the male pours the sperm cells over them, thus fertilizing them.

5. *The Circulatory System.*

The Blood.

(*a*) Place a drop of frog's blood on a slide; put vaseline around the edge of a cover slip and place it over the drop. The vaseline will prevent evaporation. Under a low power, observe that the blood consists of a fluid portion (plasma) and solid elements (corpuscles).

(*b*) Under the highest power observe that the corpuscles are of two kinds.

(1) Red corpuscles, elliptical disks tinged slightly red with hemoglobin.

(2) White corpuscles (leucocytes) generally about one third the size of the red. Observe the changes of form of one of these.

The Heart and Blood Vessels.

(*a*) Remove the pericardium carefully from around the heart.

(*b*) The ventricle. The posterior portion of the heart is the ventricle. What is its shape? Of what kind of tissue is it composed?

(*c*) The auricles. At the blunt end of the ventricle are two auricles. What is their shape? Are they thin-walled or thick-walled? What is their function?

(*d*) The truncus arteriosus. This is a large tube which starts from the base of the ventricle and divides into three blood vessels.

(*e*) The dorsal aorta. This is an artery that is formed by the union of two of the arteries arising from the truncus arteriosus. It lies in the dorsal region of the body cavity. Trace arteries from it into the fore limbs, kidneys, liver, intestine, and hind limbs.

(*f*) The pulmonary arteries. These two arteries arise one from each branch of the truncus arteriosus and carry blood to the lungs.

(*g*) The veins collect blood from the various parts of the body and carry it to the auricles. They are thin-walled instead of muscular like the arteries.

(*h*) Renal portal veins from the posterior part of the body pass to the kidney.

(*i*) The posterior caval vein carries blood from the kidneys and liver into a triangular expansion beneath the heart called the sinus venosus. From here the blood enters the right auricle.

(*j*) The two precaval veins carry blood from the lungs to the left auricle.

(*k*) Make an outline of the heart and arterial system, showing by means of arrows the direction of the blood flow.

(*l*) Make a similar diagram of the venous system.

6. *The Nervous System.*

Man excels all other animals in the development of his nervous system. It is therefore of interest to have a first-hand knowledge of the nervous system of a vertebrate which will give us a better idea of our own. Place the frog with the ventral surface down and remove the muscles and bones from the dorsal surface of the backbone and head. The brain and spinal cord may thus be exposed and examined. Great care must be exercised in this dissection so as not to injure the delicate parts to be studied.

The Brain.

(*a*) The cerebrum consists of two lobes or hemispheres lying between the eyes.

(1) How does it compare in size with the rest of the brain?

(2) Compare the cerebrum with the rest of the brain in a figure of the brain of man.

(3) Is the cerebrum of the frog smooth or convoluted? Compare with that of man.

(*b*) The two optic lobes lie back of the cerebrum. What is their function?

(*c*) The cerebellum is a single portion lying posterior to the optic lobes. Is it smooth, convoluted, or ridged?

(*d*) The medulla oblongata leads from the cerebellum into the spinal cord.

(*e*) Draw the brain as seen from the dorsal surface.

The Cranial Nerves.

(*a*) The cranial nerves extend from various parts of the brain to the eyes, nose, ears, and other parts of the body. Ten pairs of these occur in the frog. In man there are twelve pairs.

(*b*) Trace the olfactory nerves which lead anteriorly from the cerebrum.

(*c*) Carefully examine the sides of the cerebellum and medulla and identify as many pairs of cranial nerves as you can find. Try to discover to what part of the body they lead.

The Spinal Cord.

(*a*) What is the shape and length of the spinal cord?

(*b*) Is it solid or hollow?

(*c*) By what is it protected?

The Spinal Nerves.

(*a*) Turn the frog over on its back and find the pairs of nerves which are given off by the spinal cord and pass between the vertebræ of the backbone. There are only ten pairs in the frog, whereas in man thirty-one pairs are present.

(*b*) Find as many pairs as possible and trace them to the organs to which they lead.

7. *The Muscular System.*

(*a*) The movements of the frog are effected by means of muscles. The muscles that are more directly under the animal's control are called voluntary, while those that are not, like the muscles of the viscera, are called involuntary. These two kinds of muscles differ much in their structure as an examination will show.

(*b*) Voluntary or striated muscle. Tease up a minute

piece of fresh frog's muscle in 2% acetic acid; examine it with the low, and then with the high power. Observe:

(1) The elongated muscle fibers.
(2) The transverse striations, consisting of alternate dark and light bands.
(3) The nuclei are much elongated and highly refractive bodies. Notice that each fiber possesses many nuclei.
(4) Examine some muscle fibers from a specimen preserved in formalin. Note any of the above details which come out clearly.
(5) Draw a portion of a fiber in detail.

(*c*) Involuntary or unstriated muscle from the bladder of the frog. Stained and cleared preparations are best for this study.

(1) Note the general arrangement of the bundles of cells forming interlacing bands.
(2) In what way does a single involuntary muscle fiber or cell differ from a voluntary fiber (or cell)?
(3) Draw.

(*d*) Connective tissue is the substance that unites the various elements of an organ, binds together muscles, and forms tendons and ligaments.

(1) Cut out a piece of the fibrous connective tissue which binds the skin to the body and under a high power observe the fine fibers of which it is composed.
(2) Do the fibers of the tissue branch?
(3) Draw.

(*e*) The many actions the frog is capable of performing require a large number of separate muscles, only a few of

which can here be described. The hind leg, for example, can be moved up and down, backward and forward, and rotated on its long axis in either direction. The leg also may be bent at the knee or straightened out, and the foot may be flexed or extended or rotated in either direction, while the parts of the foot can perform a large number of independent movements.

The kind of motion of which a limb is capable is naturally conditioned by the form of its joints, some of which may allow only certain movements, and the number and arrangement of its muscles. In the hind leg of the frog the ball and socket joint at the head of the femur allows great freedom of movement in every direction.

The less movable end of a muscle is called its origin, the more movable end its insertion.

(*f*) Examine the muscles of the front of the thigh. Find the following:

(1) The sartorius is a thin, flat muscle extending down the front of the thigh. Origin? Insertion? Action?

(2) The adductor magnus is a large muscle on the ventral side, occupying the whole of the exterior side of the thigh. Origin? Insertion? Action?

(3) The rectus internus major is a powerful muscle on the lower side of the thigh just behind the adductor magnus. Origin? Insertion? Action?

(*g*) Examine the muscles of the back and sides of the thigh.

(1) The triceps extensor femoris is a very large muscle occupying the whole of the exterior side of the thigh. Origin? Insertion? Action?

(2) The semimembranosus is a large muscle lying along the posterior side of the dorsal surface of the thigh. About its middle it is divided by an oblique tendinous inscription. Origin? Insertion? Action?

(*h*) The muscles of the leg.

(1) The gastrocnemius lies along the flexor surface of the tibia, forming the calf of the leg. Origin? Insertion (by means of a broad, very strong tendon, the tendon of Achilles)? Action?

(2) The tibialis posticus lies between the gastrocnemius and the tibia. Origin? Insertion? Action?

(3) The peroneus lies on the side of the leg, near the gastrocnemius. Origin? Insertion?

(4) The extensor cruris is a small muscle lying on the preaxial side of the anterior half of the tibialis anticus. Origin? Insertion? Action?

(5) The tibialis anticus brevis (flexor tarsi anterior). The body of this muscle lies immediately beneath the preaxial slip of (3). Origin? Insertion? Action?

(*i*) The muscles of the abdomen.

(1) On the median portion of the ventral side of the body will be seen a large muscle, the rectus abdominis.

(2) On either side of the rectus abdominis is the external oblique muscle, the fibers of which run obliquely from the dorsal surface anteriorly to the ventral surface posteriorly.

8. *The Skeleton.*

(*a*) In the young frog the greater part of the skeleton is formed entirely of cartilage which in the adult is converted more or less completely into bone. Bones which are formed by the ossification of cartilage are known as cartilage bones. Many of the bones of the skull are formed by ossification of portions of the skin and are known as membrane bones.

(*b*) With a razor or sharp knife cut off a thin slice of hyaline cartilage from the end of the humerus, mount it on a slide and study it with a microscope. Note the clear substance and the cell spaces containing one or more cells.

(*c*) Draw.

(*d*) Study a cross section of the femur of the frog. Draw a sufficient portion of the section to show the various structures seen.

(*e*) Remove the flesh from the bones. Identify the upper and lower jaws, the nasal and optic spaces, the foramen magnum, through which the nerve cord passes, and the occipital condyles, which are rounded elevations on either side of the foramen magnum.

(*f*) The vertebral column.

(1) How many vertebræ are there? What is their function?

(2) Of what use are the short bones extending out from them?

(*g*) The fore limbs.

(1) Compare the bones of the fore limbs of the frog with those in your own arm.

(2) The fore limb of man contains one humerus, one radius, one ulna, eight carpals, five metacarpals, and fourteen phalanges.

(*h*) The hind limbs. Compare the bones you find here with those in the leg of man.

(*i*) The pectoral or shoulder girdle. These bones serve to connect the fore limbs with the backbone. Identify the sternum, scapulæ, clavicles, and coracoids.

(*j*) The pelvic girdle. This is a V-shaped set of six bones closely united. The long leg bones, the femurs, move about in concavities on either side of the pelvic girdle.

### *F.* The Development of the Frog.

Frogs' eggs should be collected from ponds in the spring and kept in glass dishes in the laboratory. They will develop without much attention and may be reared until they become little frogs. A number of different stages may be preserved in 70 % alcohol if desired.

(*a*) The following stages in the development of the egg may be found the first day after laying. Make an outline drawing of each.

(1) Undivided egg.
(2) Egg divided once (two-cell stage).
(3) Egg divided twice (four-cell stage).
(4) Egg divided four times (sixteen-cell stage).

(*b*) During the second day the following stages should be found and drawn:

(1) Early gastrula. Label: blastopore.
(2) Late gastrula. Label: yolk plug.
(3) Neural groove stage. Label: neural groove.

(*c*) On the fifth day draw the early larval stage. Label: suckers, tail, yolk, anterior end, and posterior end.

(*d*) On the eighth day draw the newly hatched tadpole as follows:

(1) Side view. Label: gills, tail, fin, mouth, suckers, and muscle segments.

(2) Ventral view. Label: operculum, eye, gill, suckers, mouth.

(*e*) Draw side view of a tadpole after it has grown two legs. Label all parts.

(*f*) Draw side view of a tadpole after it has grown four legs but before the tail has disappeared.

(*g*) Draw a young frog.

## THE PERCH

### *A.* External Features.

The body of the perch may be divided into the head, body, and tail.

1. *The Head.*

(*a*) The head contains the mouth opening, two nostrils on each side which lead into a pair of nasal sacs, and rows and groups of small pores connected with sensory canals.

(*b*) Are the eyes provided with lids? Why? What is the shape of the pupil? Is the cornea flat or convex?

(*c*) Just back of the gill cover is the opercular opening.

2. *The Body.*

(*a*) The body is covered with scales. Are they rough to the touch? Draw the hand over them both anteriorly and posteriorly.

(*b*) Remove a single scale, examine it with a lens, and draw.

(*c*) The following fins should be identified: two dorsal, one caudal, one anal, a pair of pectoral, and a pair of pelvics. How are they supported?

(*d*) Distinguish between the various sorts of fins, spines, and rays.

(*e*) Along either side of the body is a row of perforated scales which connect with a lateral line canal. What is their function?

(*f*) Just anterior to the anal fin is the urinogenital sinus, and immediately in front of this the anal opening.

(*g*) Make a sketch from the left side showing the external characters.

### *B.* Internal Organs.

1. *Open the body cavity* by a median ventral incision, thus exposing the pericardial and body cavities.

2. *Within the pericardial cavity* lies the heart.

(*a*) The ventricle lies in the midline.

(*b*) Anterior to it is the bulbous arteriosus, which leads to the truncus arteriosus, from which the blood vessels that go to the gills arise.

(*c*) The auricle lies dorsal to the ventricle, as does also the sinus venosus.

3. *The body cavity* is occupied mostly by the digestive, reproductive, and excretory systems.

4. *The digestive system* begins with the mouth cavity.

(*a*) Teeth should be noted in the jaws and roof of the mouth.

(*b*) The tongue is a small projection on the floor of the mouth cavity.

(*c*) The mouth cavity is followed by a short pharynx, on either side of which are four gill slits.

(*d*) A short esophagus follows the pharynx.

(*e*) The stomach is shaped like the letter J and consists of a long cardiac portion near the esophagus and a shorter pyloric part.

(*f*) The stomach is followed by a part of the intestine called the duodenum.

(*g*) Into the duodenum open three pouches, the pyloric cæca.

(*h*) The intestine then forms a loop which leads to the anal opening.

(*i*) A duct from the liver brings bile from the gall bladder into the intestine.

(*j*) Near the anterior end of the intestine is a large, red ductless gland, the spleen.

5. *The alimentary canal*, liver, and spleen should now be removed.

6. *The dorsal part of the body cavity* is largely occupied by the air bladder. What is its function?

7. *Beneath the air bladder are the reproductive organs.*

(*a*) The paired testes in the male are elongated, whitish sacs. The spermatozoa formed in them pass out through the urinogenital opening.

(*b*) The ovaries of the female are usually larger and more yellowish than the testes.

8. *The kidneys* may be exposed by removing the dorsal wall of the air bladder. They are long, lobulated dark-red bodies, one on either side of the vertebral column.

(*a*) The ducts from the kidneys, the ureters, unite to form a single tube, the urethra.

(*b*) The urinary bladder opens into the urethra.

9. *Make a sketch* showing the systems of organs described above.

## BIRDS

Birds are difficult to obtain for purposes of dissection and should therefore be studied in the field, if possible, or caged birds may be observed in the laboratory. Birds that are stuffed and mounted afford opportunities for studying external features.

### I. *FIELD STUDIES.*

The best time to study birds in the field is in the early spring before the leaves have appeared on the trees, since at that time they are not hidden by the foliage. Early morning is the most general feeding time for birds, and hence the time when they are most active.

Birds are shy creatures and as a rule cannot be very closely approached. A pair of sharp eyes should therefore be supplemented if possible by a field or opera glass. Such a glass can be purchased for about five dollars.

It is best to study birds alone or in small groups, since they are easily frightened by noises. If it is necessary to search for birds with a number of companions, every one should be as quiet as possible.

The colors of birds cannot be seen very well when looking towards the sun. It is consequently best to keep the sun at your back if possible.

The calls or songs of birds are frequently heard before the birds themselves are seen, and furnish an excellent means of locating the singers. After the foliage becomes dense it is difficult to see the birds at all, and a knowledge of

songs and call notes is then of great value. Try to distinguish between the call note and songs of each bird and of different birds. This is not an easy thing to do, but persistent effort extended over a period of years will result in success.

The plumage of birds often differs at different times of the year. That of the male is often brighter than that of the female and of different color. Try to distinguish between the males and females, and between the young and adults.

Directions for attracting birds by making bird baths, planting trees, shrubs, and vines that bear edible berries, feeding birds in winter, and making bird houses will be found in the textbook in Chapter XXXVII.

The results of observations in the field should be recorded in a notebook under the following headings:

1. Name and Sex.
2. Comparative Size.
3. Dates when seen.
4. Number seen.
5. Distinctive Markings.
6. Habitat.
7. Habits. (Solitary, flocks, shy, friendly.)
8. Food.
9. How Food is Obtained.
10. Movements. (Walking, perching, climbing, hopping, running.)
11. Flight. (Straight, swift, wavy, slow, irregular, upward.)
12. Nesting Habits.

(*a*) Location of nest.

(*b*) Dates when built.

(*c*) Materials, architecture, etc.
(*d*) Eggs (number, size, color).
13. Remarks.

Another method of recording observations is to make a bird calendar in which the birds are arranged in four groups as follows:

1. *Permanent Residents.* Birds that remain with us throughout the entire year.

2. *Summer Residents.* Birds that come in the spring, remain during the nesting season, and go south in the autumn. The dates of the first arrival and last departure should be included.

3. *Migrants.* Birds that pass through in the spring on their way to their nesting grounds in the north, and again in the autumn on their way to their winter homes in the south. Dates should be included as in 2.

4. *Winter Residents.* Birds that come to us from the north, remain during the winter, and move north again in the spring.

The following is a part of a bird calendar to illustrate the method of recording names and dates:

*Observations made at Ann Arbor, Michigan,* 1914.

1. *Permanent Residents.*

Downy Woodpecker.
Blue Jay.
Chickadee.
Great Horned Owl.

2. *Winter Residents.*

Evening Grosbeak.
Tree Sparrow.

3. *Migrants.*

White-throated Sparrow. May 1–20; Sept. 14–Oct. 20.
Magnolia Warbler. May 10–15; Sept.
Golden-crowned Kinglet. April 15–25; Sept. 20–Oct. 6.

4. *Summer Residents.*

Robin. March 10–Oct. 20.
Blue Bird. March 10–Oct. 3.
Song Sparrow. March 15–Oct. 3.

II. *LABORATORY STUDIES*

(*a*) The body of the bird may be divided into head, neck, and trunk.

(*b*) The head bears a pointed, horny beak.

(*c*) The nostrils are oblique slitlike apertures near the base of the beak.

(*d*) The eyes are large and laterally situated; each is provided with upper and lower eyelids, and a third lid, the nictitating membrane.

(*e*) Below and slightly behind the eyes on either side of the head is an external auditory opening.

(*f*) The neck is long and flexible, enabling the bird to use its beak for may purposes.

(*g*) The trunk is rather spindle-shaped, thus offering little resistance to the air during flight. It is terminated by a short tail.

(*h*) The feathers of the bird are principally of the sort known as contour feathers. Pull out one of the large wing or tail feathers, and note the following parts:

(1) The stem is the entire central rod; this consists of a lower, hollow portion,

(2) The quill, and a distal, solid portion,

(3) The shaft ; on either side of the shaft is
(4) A vane.

(*i*) Examine part of the vane under the microscope, and note that it consists of a number of parallel filaments, the barbs, which bear smaller processes, the barbules, and these in turn are provided with hooklets.

(*j*) Draw an entire feather and a single barb.

(*k*) It will be found upon plucking a bird that only certain definite areas bear feathers.

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